



This document contains the Executive Summary and Introduction for the Indicator Development for Estuaries report. EPA-842-B-07-004 The remainder of the document can be downloaded from:

<http://www.epa.gov/owow/estuaries/indicators/>

Indicator Development for Estuaries

February 2008

EXECUTIVE SUMMARY

The National Estuary Program (NEP) was established by Congress in 1987 under Section 320 of the Clean Water Act, to promote and restore the health of nationally significant estuaries, while concurrently supporting beneficial uses of the estuary's natural resources. Under the NEP, the Administrator of the U.S. Environmental Protection Agency (EPA) is authorized to convene Management Conferences to identify priority problems within these estuaries and develop a Comprehensive Conservation and Management Plan (CCMP) to address those problems. Since the programs inception, 28 NEPs around the Nation have been nominated and accepted into the National Estuary Program.

Each NEP is responsible to track the progress of CCMP implementation and to monitor associated ecological conditions in the estuary. Many NEPs share common priority problems or key management issues including: habitat, pathogens, freshwater inflow, nutrients, fish and wildlife, invasive species and toxics. However, each NEP's goals and issue-specific management actions are unique and, therefore, the specific data collected to track CCMP implementation progress and monitor ecological conditions, varies widely among the NEPs. Indicators developed are unique ranging from horseshoe crabs in Delaware Estuary to alligator nests in Barataria-Terrebonne National Estuary Program. Most of the NEPs share two or more of the key management issues, but may approach them differently based on differing cultural, economic and political characteristics. Each NEP reports on the status of indicator development and implementation yearly.

Overview of Environmental Indicators

"Environmental Indicators are specific, measurable markers that help assess the condition of the environment and how it changes over time. Both short term changes and general trends in those markers can indicate improved or worsening environmental health." (Based on Barbara Keeler, personal communication, April 18, 2006)

"Monitoring the status of an estuary is a complex undertaking. Measuring water and living resource quality at all times, in all locations, and at all depths would be prohibitively expensive." (EPA, 1994) Tracked over time, indicators can provide cost-effective information on the status and trends of a system and the effectiveness of management actions. Indicators let us express complex information as simple and useful measures of status and trends. Indicators can provide measures of the success of management actions and allow for mid-course corrections. They can provide qualitative and quantitative measures that can be useful on local, regional or national scales both on a temporal and spatial basis. Indicators can be used to inform diverse audiences including: environmental managers, scientists, resource managers and the public.

EPA's Ocean and Coastal Protection Division (OCPD) evaluated the usefulness of data being collected by individual NEPs as national environmental indicators. EPA decided to focus an initial evaluation on two key estuarine challenges: habitat degradation/loss and nutrient overloading. To achieve this objective, OCPD formed an NEP Indicators Workgroup to review and assess NEP data. The Workgroup concluded that indicator information collected by the NEPs could be useful on a local, regional, as well as, a national scale.

As a result of this effort and the growing importance of indicator development, OCPD decided to offer technical support to the NEPs for indicator development. Once the NEP selects appropriate indicators and the Management Committee formally adopts them, they are incorporated into the Monitoring Plan. The broad experience of the NEPs in indicator development led to the preparation of this “Indicator Development for Estuaries” manual, which provides a framework and a logical, stepwise process for selecting, validating and implementing indicators. Based on the NEPs’ expertise, it became clear that this valuable expertise could be shared with other NEPs currently developing indicators and with estuaries facing some of the same issues.

The Manual

The Manual is organized to provide the user with a logical, stepwise process in developing and implementing indicators for the estuarine environment. It is organized under seven major headings:

- **Introduction**
Provides the background for the identification and use of indicators;
- **Planning the Program**
Covers spatial scale, establishing a steering committee, key management issues, and baseline assessments;
- **Conceptual Models Development**
Discusses conceptual model development and use;
- **Indicator Specification**
Presents concept, feasibility, response and interpretation, and usefulness of indicators;
- **Monitoring Plan Development and Modification**
Covers development and revision of the monitoring plan;
- **Indicator Implementation**
Formal adoption, funding, communication, monitoring plan implementation, data collection and analysis plans;
- **Indicator Reassessment**
Reassess every five-years or less, reevaluation of each indicator as needed.

The Manual is tabbed for easy access to the chapter of interest and allows the user to focus on the appropriate step in the process.

Case studies of the Barataria-Terrebonne NEP, New Hampshire NEP Indicator Development Process and Northeast Coastal Indicator Workshop are provided to give the reader examples of how other programs have approached indicator development following this process. Additionally, to provide the reader with a quick overview, further understanding of programs, and references to indicator development, a list of indicators selected by NEPs and other programs and a list of available indicator-focused resources have also been included.

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INTRODUCTION

This manual has been prepared to provide information on indicator development and to offer a framework for the development of indicators for use in coastal waters. The goal is to provide:

- Background information on indicators and why indicators should be developed.
- Information on indicator development by Federal programs and the advantage of developing indicators for use on more than just a local or regional scale.
- Information on who should develop indicators.
- Lessons learned by programs.
- Step-by-step process of how to select indicators.
 - Program needs for indicator development as related to the stage of program development.
 - General information on developing monitoring plans for indicators, and incorporating and implementing indicator programs.

Throughout the document, statements and examples from the U.S. Environmental Protection Agency's (EPA) National Estuary Programs (NEPs) and other Federal, regional, and local programs are highlighted.

WHAT ARE INDICATORS?

The definition of an indicator varies from program to program. The following are examples of the definitions of "indicator" used in differing applications:

"Environmental Indicators are specific, measurable markers that help assess the condition of the environment and how it changes over time. Both short term changes and general trends in those markers can indicate improved or worsening environmental health." (Based on Barbara Keeler, personal communication, April 18, 2006)

"6. Ecol. A plant or animal that indicates, by its presence in a given area, the existence of certain environmental conditions." (Random House, 2001)

"An Indicator is a particular characteristic or reference marker used to measure whether an outcome is being achieved." (EPA, 1994)

"Indicators are objective descriptions of a particular aspect of our natural, economic, or social environment." (The Heinz Center, 2003)

It is clear that the varied definitions of an indicator reflect the application, the complexity of language used, and the degree of precision required based on programmatic context.

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Implementation of indicators depends on the systems to which the indicators are being applied.

Indicators are used to summarize complex information into a simplified and useful form to facilitate the measurement of status and trends. Indicators communicate information, quantify responses, and simplify information about complex data. Indicators can be a cost-effective, accurate alternative to monitoring the individual components of a system. Therefore, indicators can be an effective means of assisting groups in tracking the progress of their programs (EPA, 2003a).

“When tracked over time, an indicator can provide information on trends in the condition of a system. In order to develop an appropriate environmental indicator, it must be directly linked to the cause, effect, or action it is tracking. Ideally, indicator development should be preceded by the development of an assessment question” (EPA, 2003a). Specifically, indicators should be linked to the issues and goals specific to an estuary program’s Comprehensive Conservation and Management Plan.

For NEPs: indicators should be linked to the issues and goals specific to the estuary program’s Comprehensive Conservation and Management Plan.

As stated above, indicators can assist the programs in tracking progress toward their goals. Indicators that are not linked to an estuary program’s goals and objectives will not support efforts to assess the progress of management actions. Where possible, local and regional indicators can augment national assessments; therefore, to the degree possible, comparable indicators should be developed to support all levels of objectives.

Indicators are invaluable for measuring the achievement towards milestones and progress in meeting environmental goals. Indicators can also function as early warning signals for detecting relatively small adverse changes in environmental quality. For example, the change in air and ocean temperatures throughout the world has been used for years as an indicator of global warming, while the change in land use within an area can be an indicator of changes in human activities. Although these require very different types of measurements, both are indicators of human influence on our ecosystem.

The following definitions illustrate the use of different levels and types of indicators:

Worldwide Indicator

An indicator with worldwide applicability as a response to a common stressor (*e.g.*, global warming) or as an indicator with value regardless of geographic location (*e.g.*, water temperature).

Cultural/Societal Indicator

An indicator that can measure human activity—specifically, the impact of human activity on ecosystem integrity or human response to ecosystem stressors. Examples of the former

include population, impervious land cover, and wetland filling; examples of the latter include fish consumption advisories and beach closure days.

Economic Indicator

An indicator that normally shows general trends in the economy. Examples of an economic indicator include unemployment levels, the Consumer Price Index, industrial production, bankruptcies, and stock market prices.

Ecological Indicator

An indicator that characterizes measurable (quantifiable) characteristics related to the structure, composition, or functioning of ecological systems (EPA, 2003b). Generally biotic in nature, these can be a specific individual measurements, an index of measures, or a model that characterizes an ecosystem or one of its critical components (EPA, 2003b). An important aspect of an ecological indicator is that it quantitatively estimates the condition of ecological resources, the magnitude of stress, the exposure of biological components to stress, or the amount of change in condition (EPA, 2003b).

Environmental Indicator

An indicator that measures the state of air, water, and land resources, pressure on those resources, and the resulting effect on ecological and human health. An environmental indicator shows progress in making air cleaner and water purer and in protecting the land (EPA, 2003b). This type of indicator measures environmental conditions (*e.g.*, human health, quality of life, and ecological integrity) or stressors that provide useful information on patterns and trends.

Delaware Inland Bays Program—Definition of an Environmental Indicator

“As commonly employed, an environmental indicator is a discrete measure of one aspect of environmental quality that can be used alone or in combination with other indicators to deliver a message or tell a story related to the overall environmental health of an ecosystem.” (Price and Huerta, 2001)

Charlotte Harbor NEP (CHNEP)—Definition of an Environmental Indicator

“An environmental indicator is defined here as a measure, an index of measures or a model that characterizes the ecosystem or one of its components.” (CHNEP, 2004)

Programmatic Indicator

A program, policy, or administrative response to an environmental problem. These performance measures may or may not lead to detectable improvements in environmental conditions.

Each of these indicator types can be broadly applied or can be useful in certain situations. In the examples given above, global warming is considered a worldwide indicator, while changes in human activities are considered a cultural/societal indicator. This manual

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focuses on the development of ecological or environmental indicators on a local, regional, or national level. Even so, the steps outlined can be used to develop indicators for other applications.

For more information on cultural/societal and economic indicators, the following websites are suggested:

- Cultural Indicators—Contact the United Nations Educational, Scientific, and Cultural Organization - http://www.unesco.org/culture/worldreport/html_eng/wcr5.shtml
- Societal Indicators—Government Performance and Results Act – <http://www.ed.gov/offices/OUS/PES/gpra/OPM.html>
- Economic Indicators—see <http://www.investorwords.com/cgi-bin/getword.cgi?1643&economic%20indicator>

WHY SHOULD INDICATORS BE DEVELOPED?

In the late 1960s, the United States began to develop an awareness of the importance of preserving and protecting our nation's coastal waters, including the Great Lakes. Data from all over the United States showed that industrial and human practices had degraded the nation's coastal waters, along with the lives and livelihoods of populations living along the coast.

Programs and Other Initiatives

For over 40 years, the nation has worked to improve its coastal waters by enacting important legislation (see below) and developing a range of programs and initiatives that protect the coastal environment. Among these are programs that focus attention on identifying impacts that degrade the U.S. coasts on an estuarine, regional, and national level. Once the impacts are identified and their causes understood, these same programs work to develop plans to prevent further degradation of the area and develop ways to improve these ecosystems to a desirable condition. One tool that is used to track the environmental response to implementation of these programs is the environmental assessment program; a key component of the environmental assessment program is the inclusion of indicators.

Legislation

In 1972, Congress enacted both the Federal Pollution Control Act (renamed in 1977 to the Clean Water Act [CWA]) and the Coastal Zone Management Act (CZMA) to begin protecting and cleaning our coastal waters. These acts and their revisions also created several national initiatives to improve our estuaries of national significance, including the NEPs and National Estuarine Research Reserve (NERR) programs. Other agreements and acts have created other programs such as the Great Lakes Program to focus on specific bodies of water.

Clean Water Act—The CWA established a structure through the EPA for implementing and regulating discharges of pollutants into the waters of the United

States and to develop pollution control programs such as setting wastewater standards for industry. The CWA granted EPA the authority to set water quality standards for all contaminants in surface waters. A revision in 1987 created the NEP to (1) identify nationally significant estuaries that are threatened by pollution, development, or overuse, and (2) promote comprehensive planning for and conservation and management of nationally significant estuaries (for more information see <http://www.epa.gov/region5/water/cwa.htm>).

Coastal Zone Management Act—The CZMA established a program through the National Oceanic and Atmospheric Administration (NOAA) to “preserve, protect, develop, and where possible restore or enhance the resources of the coastal zone for this and succeeding generations” (CZMA of 1972 as amended by P.L. 104-105 The Coastal Zone Protection Act of 1996, Section 303(1); NOAA, 2005). The CZMA established the NERRs and a process for coastal states to develop Coastal Zone Management Programs (CZMPs). The CZMPs provide “mechanisms to improve the cooperation and coordination among state agencies and with other levels of government and the public” (The Heinz Center, 2003).

These two acts were, and still are, the leading legislation for the protection and restoration of America’s coastal environment. Through the adoption of these acts, many programs have started to monitor, protect, and restore the U.S. coastal areas and marine resources.

Since the development of the CWA and CZMA, Federal agencies and states have been working to improve their coastal waters as specified by these acts, but no specific measurement of the improvements has been conducted. In 1993, the Government Performance and Results Act (GPRA) called for “Federal agencies to undertake efforts to measure their performance and the effectiveness of their programs” (The Heinz Center, 2003), including those programs mentioned above. The process focused on developing a series of indicators that could track the effectiveness of these programs and provide quantifiable measures that demonstrate the response of our nation’s coastal waters overall. Since the enactment of GPRA, programs like the National Coastal Assessment (NCA) have been implemented by EPA to measure improvements nationwide (see <http://www.epa.gov/emap/nca/> for more information on the NCA).

WHO IS DEVELOPING INDICATORS?

Organizations throughout the world and the United States have begun developing indicators, including programs by the World Bank, the Organisation for Economic Co-operation and Development (OECD), and Federal, state, and local agencies. Some programs only develop indicators that can be used in a specific location, while others are developing indicators to track changes in ecological conditions throughout entire regions. Several Federal programs have initiatives to develop indicators. The following discussions provide short descriptions of some of these initiatives.

EPA's Environmental Indicator Initiative

On November 13, 2001, EPA Administrator Christine Todd Whitman announced an "Environmental Indicators Initiative" to improve EPA's ability to report on the status of and trends in environmental conditions and their impacts on human health and the nation's natural resources (EPA, 2005a). The Indicators Initiative also identified where additional research, data quality improvements, and information were needed. EPA's long-term goal is to improve indicators and the data that are used to guide the Agency's strategic plans, priorities, performance reports, and decision-making (EPA, 2005a). EPA's Office of Environmental Information and the Office of Research and Development (ORD) are the lead contacts for this program.

One of the key products of the Environmental Indicators Initiative is EPA's Draft Report on the Environment 2003 (EPA, 2003b). The document reports on the environmental conditions and human health concerns of the environment, using available national-level data and indicators. The report includes data on human health, ecological conditions, clean air, "pure water," and better-protected land. Under "human health," the report explores trends in diseases, human exposure to environmental pollutants, and diseases thought to be related to environmental pollution (EPA, 2003b). The nation's "*ecological condition*" is determined by looking at land use and cover, living resources, and pressures on living resources and our sustainable natural resources. To establish a national baseline for "*clean air*," the report examines outdoor air quality—its impact on human health and ecosystems—and indoor air quality impacts on human health. The "*pure water*" theme examines drinking water and food safety, recreational water use, the condition of the nation's water resources, and the living resources sustained by them. To ensure "*better protected land*" in the future, the report explores existing land cover and use, activities that affect the condition of the American landscape, the location and condition of degraded land, and various conservation and management practices (EPA, 2003b). The 2003 report is available at <http://www.epa.gov/indicators/roe/index.htm>.

EPA's National Estuary Program

EPA established the NEP to promote and restore the health of nationally significant estuaries, while simultaneously supporting all beneficial uses of the estuaries' natural resources. Under the NEP, the Administrator of the EPA is authorized to convene Management Conferences to identify priority problems within these estuaries and develop a Comprehensive Conservation Management Plan (CCMP) to address those problems. At present, there are 28 NEPs throughout the United States and 27 NERRs. Figure 1 shows the biogeographic coverage of the NEPs and the general vicinity of the NERRs.

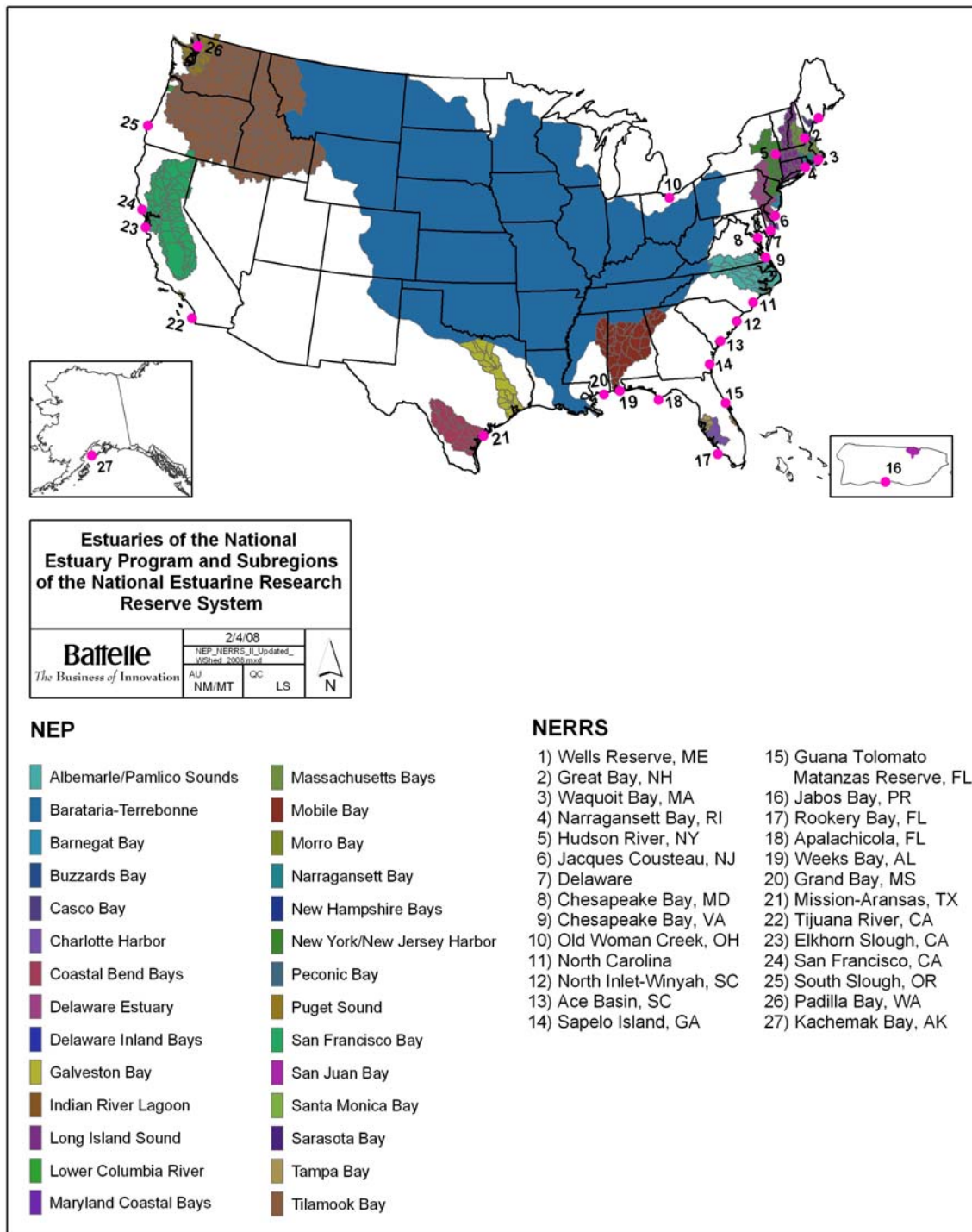


Figure 1. Map of the estuaries in the National Estuary Program (NEP) and National Estuarine Research Reserve (NERR) System

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Over the past few years, EPA's Oceans and Coastal Protection Division (OCPD) determined the need to evaluate the usefulness of data being collected by individual NEPs as national environmental indicators—inclusive of indicators associated with restoration actions undertaken and changes in overall ecological condition—of NEP progress. NEP indicators must be directly linked to the cause, effect, or action that is proposed in the CCMP or monitoring plan. EPA considers the establishment of assessment questions and the development of a framework or model of the system relevant to the assessment question(s) important to the process of developing a suite of indicators. It is the responsibility of each NEP to track the progress of CCMP implementation and monitor associated ecological conditions in the estuary. Many NEPs share common priority problems; however, each NEP's goals and issue-specific actions are unique and, therefore, the specific data collected to track CCMP implementation progress and monitor ecological conditions varies widely among the NEPs (NCIW, 2004). Both the Barataria-Terrebonne NEP (Appendix A-1) and New Hampshire NEP (Appendix A-2) followed the process of developing indicators based on the goals and objectives of their CCMPs. Appendices A-1 and A-2 highlight the indicator development process of these two NEPs.

NEP indicators must be directly linked to the cause, effect, or action that is proposed in the CCMP or monitoring plan. EPA considers the establishment of assessment questions and the development of a framework or model of the system relevant to the assessment question(s) important to the process of developing a targeted suite of indicators.

EPA's Great Lakes Program

EPA's Great Lakes National Program Office (GLNPO) works with agencies in Canada to manage the shared resources of the Great Lakes under the Boundary Waters Treaty of 1909, the 1987 Great Lakes Water Quality Agreement, and portions of the CWA and the Clean Air Act. Through this program, EPA works with various Federal and state agencies to manage the ecosystems of the Great Lakes, including addressing issues such as “reducing toxic substances, protecting and restoring important habitats, and protecting human/ecosystem species health” (EPA, 2004). Each lake has its own Lakewide Management Plan, which has been developed to manage the top issues within that lake. Since 1994, the U.S. and Canadian governments have hosted biennial State of the Lakes Ecosystem Conferences (SOLECs), which have focused on reporting the health of the Great Lakes using indicators. “The SOLEC process is a rare opportunity to bring stakeholders together to identify common objectives and data needs, and to encourage cooperative data collection, evaluation, and reporting.” (Environment Canada, 2005).

NOAA National Coastal Management Performance Measurement System

The National Coastal Management Performance Measurement System is part of an ongoing effort by the NOAA to work with coastal states to assess the effectiveness of the CZMA as carried out by coastal management programs and NERRs. This system responds to Congressional requests to assess the national impact of coastal management programs and to report to the Appropriations Committees on progress in meeting the

objectives of the CZMA. NOAA's Office of Ocean and Coastal Resource Management (OCRM) is responsible for developing and implementing the performance measurement system. OCRM has worked with the coastal management programs and reserves to develop contextual and performance indicators related to coastal hazards, habitats, public access, coastal community development, coastal dependent uses, coastal water quality, government coordination and decision-making, education, stewardship, and research. In 2004, OCRM implemented a phased approach for collecting information on the identified indicators. Under Phase I of the coastal management programs, most of the performance indicators in a subset of states will likely be implemented. The reserves will phase in indicators over time, with Phase I limited to indicators with known data available. In addition to assessing management outcomes, NOAA will prepare annual assessments of activities funded under the CZMA. NOAA is also working with the states, other Federal agencies, and stakeholders to develop a consistent framework for a national state of the coast report that will serve as a report card on the condition of America's coastal resources (NCIW, 2004).

National Park Service (NPS) Vital Signs Monitoring Program

Fundamental to fulfilling the NPS mission of managing park resources "unimpaired for the enjoyment of future generations" is knowing the condition of natural resources in each national park. The National Parks Omnibus Management Act of 1998 established the framework for fully integrating natural resource monitoring and other science activities into the management processes of the National Park System. Section 5934 of the Act requires the Secretary of the Interior to develop a program of "inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources." In the Appropriations Bill for Fiscal Year 2000, Congress reinforced this message by calling on the NPS to implement a "systematic, consistent, professional inventory and monitoring program ... that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data." The 2001 NPS Management Policies specifically directed the Service to inventory and monitor natural systems in national park units, and to use the results of monitoring and research to develop appropriate management actions. The NPS has implemented a three-tiered strategy to institutionalize natural resource inventory and monitoring throughout the agency: (1) completion of basic resource inventories upon which monitoring efforts can be based; (2) creation of experimental prototype monitoring programs to evaluate alternative monitoring designs and strategies; and (3) implementation of operational monitoring of critical parameters (*i.e.*, "vital signs") in all natural resource parks. To implement vital signs monitoring, all parks with significant natural resources (about 270 nationwide) have been grouped into 32 monitoring networks linked by geography and shared natural resource characteristics. Network parks share funding and professional staff to plan, design, and implement an integrated long-term monitoring program (NPS, 2003; NCIW, 2004).

WHO SHOULD USE INDICATORS?

Any program that monitors a condition can develop an indicator. One example of a monitoring program that uses indicators is a weather forecast. Meteorologists use several

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measurements and techniques (*e.g.*, temperature, wind speed, and precipitation) to forecast the weather. Each item used is an indicator of something. If the temperature is below freezing and the radar says there is precipitation, then more than likely snow, sleet, or freezing rain is falling in the area. Thus, indicators can be used by anyone.

Today, a large percentage of the nation's population lives within coastal areas, which has created environmental pressure on coastal resources. Each coastal program that is developed to address these environmental pressures, such as the NEPs and NERRs, develops goals for its area. Along with these goals, measurement programs and indicators are established. The use of indicators supports the determination of whether an ecosystem is sustainable by helping to track the status and trends of an ecosystem. Typically, coastal programs choose indicators that track progress in a local area. However, several agencies may join their efforts, such as those instituted by the Gulf of Maine [GOM] Council, to develop indicators on a regional level. Federal agencies, including EPA, are interested in indicators that also determine the overall national health of coastal ecosystems. Although the application of indicators ranges in scale, the need for indicator development is the same depending on whether the indicators are being established for local, regional, or national efforts.

Estuary programs should consider including indicators from the National Coastal Conditions Report (NCCR I and II [EPA 2001 and 2005b]) to assist in collecting data on the overall health of the nations coastal areas.

At the regional level, coastal programs such as the NEPs develop CCMPs. The purpose of a CCMP is to identify issues that require management strategies to best address and resolve the issues. As part of the CCMP development, program objectives are defined (for example, "Ensure public health associated with contact recreation and seafood

For NEPs: Indicators should provide the basis to answer their CCMP questions.

consumption" [CBBEP, 1998]). To determine whether these objectives have been met, monitoring programs are developed to measure progress. As part of these monitoring programs, indicators are selected for measurement. Indicators provide the basis to answer the CCMP questions. Together,

indicators and a monitoring plan ensure that policies and management efforts are effective in tracking the status of an ecosystem. Appendix A-1 and Appendix A-2 provide more details on the Barataria-Terrebonne NEP and New Hampshire NEP process of developing monitoring programs and indicators.

Coastal waters are not defined by state borders, making it critical that neighboring communities cooperate to address environmental concerns. Joint efforts are required to identify and prioritize issues and questions. The need for regional indicators has become a forefront issue as the necessity for coordinated monitoring increases. Regional indicators serve to bring consistency to the process of informing decision-makers and the public on the status of the area or region. This type of effort helps address gaps between monitoring and management, such as consistent monitoring approaches, data reporting to

ensure the work is relevant, and allocation of resources. For regional indicators to be successful, the use of the indicators must be consistent throughout the system to show overall trends.

A national approach to developing indicators will provide an integrated assessment framework for scientists, decision-makers, managers and, ultimately, the public. Federal agencies are required by the GPRA to report the status of the nation's coastal waters and their national programs. The nation's decision-makers want to know what the present conditions of estuarine resources are in the United States, how the conditions are changing, and what causes those changes. Therefore, a set of indicators must be developed to correlate data from the nation's coastal waters into one data set that can be analyzed for overall coastal ecosystem health. Federal, state, and local governments, as well as all interested parties, must be involved in developing a national effort. This type of alliance will then create a system that will be used locally and nationally.

“The more information that can be supplied to managers and regulatory officials from a united approach with a common message, the more likely the message will be heard” (ANCMS, 2003).

Indicators offer a better understanding of a particular estuary, region, or the nation and provide a check of the health of valuable and productive resources. Whether indicators are developed at the local, regional, or national level, the need for them continues to grow as the nation's focus emphasizes the quality of life and the health of our coastal waters. The indicator development process is one of progress toward a shared vision or goal.

The NCA Program is just one effort to develop a national list of indicators on which to evaluate overall changes in the environmental health of U.S. waters. This effort is led by EPA's ORD and Office of Water, with support from NOAA, U.S. Fish and Wildlife Service, and the U.S. Geological Survey (USGS).

The NCA has prepared two National Coastal Condition Reports (NCCRs) (see <http://www.epa.gov/emap/nca/index.html>) which report on the quality of the nation's coastal waters, sediments, benthic communities, habitats, and fish species. To develop this report, the NCA prepared a list of indicators for which it collects data from a variety of local, regional and national programs. The callout box on page 12 lists indicators tracked by the NCA. Figure 2 is an example from the *National Coastal Condition Report II* of how the NCA synthesizes and reports the data collected (EPA, 2005b).

National Coastal Assessment Indicators

Water Quality Index

- Nutrients
 - Nitrogen (dissolved inorganic nitrogen)
 - Phosphorus (dissolved inorganic phosphorus)
- Chlorophyll-*a*
- Water clarity
- Dissolved oxygen (DO)

Sediment Quality Index

- Sediment toxicity—10-day toxicity test with the amphipod *Ampelisca abdita*
- Sediment contaminants
 - Metals—arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc
 - Organic compounds—acenaphthene, acenaphthylene, anthracene, fluorene, 2-methyl naphthalene, naphthalene, phenanthrene, benz(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, pyrene, low-molecular-weight polycyclic aromatic hydrocarbon (PAH), high-molecular-weight PAH, total PAHs, 4,4'-dichlorodiphenylethylene (4,4'-DDE), total dichlorodiphenyltrichlorethane (DDT), total polychlorinated biphenyls (PCBs)
- Total organic carbon

Benthic Index

- Benthic community diversity
- Presence and abundance of pollution-tolerant species
- Presence and abundance of pollution-sensitive species

Coastal Habitat Index

- Average of the mean long-term decadal wetland loss rate (1780-1990) and the present decadal wetland loss rate (1990-2000).

Fish Tissue Contaminants Index

- Metals—arsenic, cadmium, mercury, selenium
- Organic compounds—chlordane, DDT, dieldrin, endosulfan, endrin, heptachlor epoxide, hexachlorobenzene, lindane, mirex, toxaphene, PAH (benzo(a)pyrene), PCB

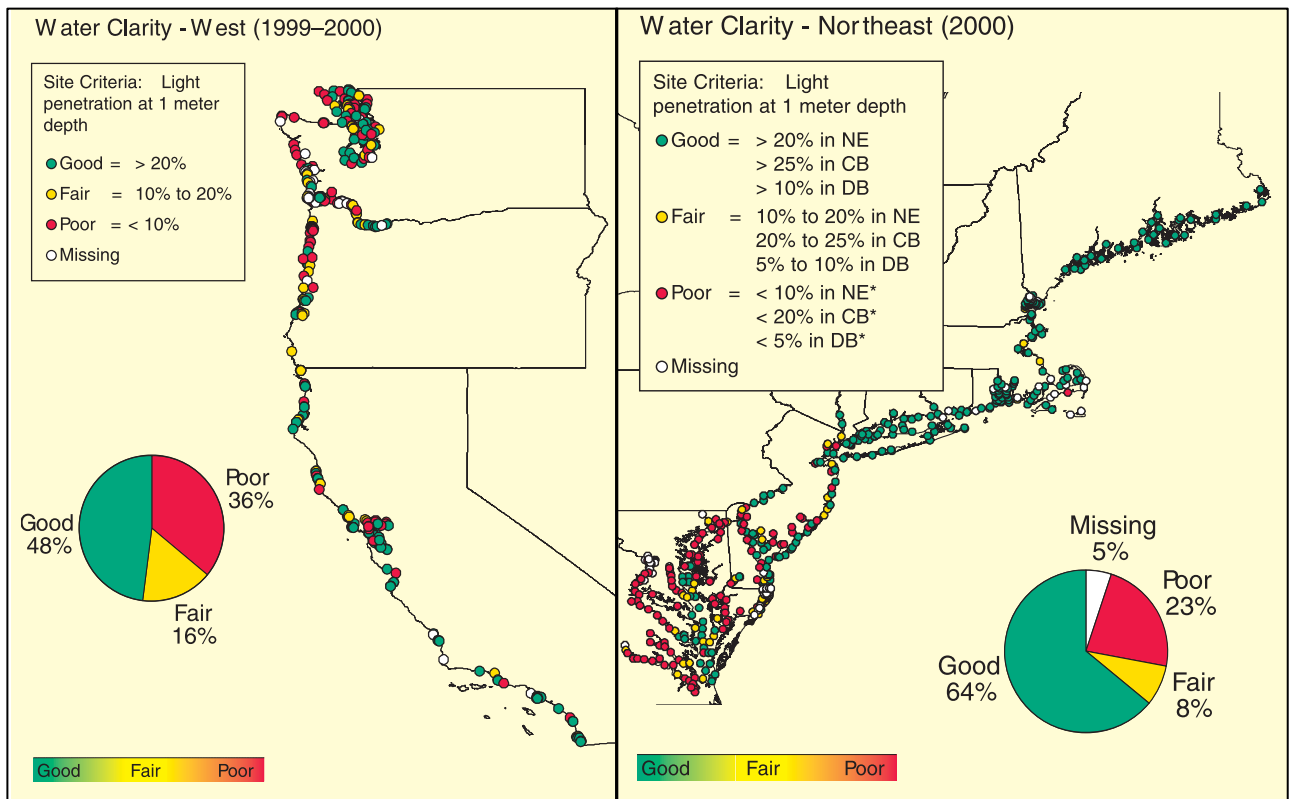


Figure 2. National Coastal Assessment Synthesis of Water Clarity Data (EPA, 2005b)

Although these indicators are reviewed on a larger (national) scale, the same indicators are also useful on the regional and local level (see the *Sneaker Index* callout box on page 35 for an example of how water clarity is used on a local level). It is suggested that these indicators be considered when developing local indicator sets, so that local data can be compared with this national data set.

LESSONS LEARNED DURING PREVIOUS EFFORTS TOWARD INDICATOR DEVELOPMENT

A number of programs have spent considerable time and effort over several years to develop appropriate indicators. Since this process can be daunting to any new group, it is always helpful to find out what other programs experienced, especially any lessons learned. For the Northeast Coastal Indicators Workshop (NCIW), conducted in January 2004, the Maine State Planning Office prepared “Tapping the Indicators Knowledge-base” (Pidot, 2003). This document summarizes information on lessons learned collected from several Federal, state, and local programs throughout the United States. The key findings of this document are summarized below. The details can be found at http://www.gulfofmainesummit.org/docs/Lessons_Learned_Report.pdf.

Lessons Learned from the Northeast Coastal Indicator Survey

- Developing indicators and indicator-based products is a lengthy process.
- Query the members of the target audience throughout the process.
- Involve a wide range of individuals from the beginning.
- Select indicators with good prospects for long-term monitoring.
- Replace an indicator if it does not produce meaningful results.
- Allow time for important decisions.
- Report clear and direct linkages between the indicators and the results/needs.
- Develop separate simplified reports developed for managers and policy makers.
- Indicators need to be sold to the managers and policy-makers.

Each lesson learned is important to every program attempting to develop indicators because they are all interconnected. As noted in the first bullet, development of indicators is not something that can be done in a day or two. To develop indicators that will be useful to the program, each group must carefully look at its issues, ecological system, and available data to determine the best indicator for that situation. It will take time to pull this information together in a way that can be reviewed. However, it is important so that the indicators selected have good prospects for long-term monitoring and effective results, but also so that the indicators are clearly linked to the items that need to be reported. Part of the reason indicator development takes time is because members of the target audience need to be queried, and a wide range of individuals must be involved to ensure that the questions the public and environmental managers need answered are addressed. In the case of the NEPs, this step is conducted for their CCMP development; however, the data necessary to choose indicators may not be consolidated during CCMP development.

Adequate information must be collected prior to indicator development so that indicators with good prospects for long-term monitoring and effective results are selected.

Another lesson learned is that once indicators are developed, the process does not stop. What looks good in theory does not always work in practice; therefore, once the data collection begins, the indicators should be further evaluated to determine whether the indicators are producing meaningful results and are useful to the end users. The indicators selected and information collected also need to be reported to the managers; therefore, the process of developing indicators should not be rushed, but it should also not be avoided. If the indicators supply useful information, indicator development can help save program funds or justify additional funds.

The last important lesson learned is that there are distinct advantages to indicator development; however, if poor choices are made, there can be some disadvantages and consequences. Indicators can help programs track changes efficiently, thus being more

cost-effective and less time-consuming than monitoring a number of items. However, if the indicators selected do not communicate the information needed, then money can be wasted and important data needed to determine whether changes have occurred can be lost. Therefore, indicators must be selected wisely and reviewed often to ensure they meet the needs of the program.

Long Island Sound Study (LISS)—Lessons Learned

The biggest challenge during indicator development was the significant commitment of time necessary for developing indicators (Pidot, 2003).

Casco Bay Estuary Partnership (CBEP)—Lessons Learned

“...with a small budget and staff, Diane Gould reported that the CBEP staff has been challenged by the necessity of spreading itself out over all of the issues and topics deemed important (Pidot, 2003).

INDICATOR DEVELOPMENT PROCESS

As noted in the lessons learned section, there are several necessary steps to follow when developing indicators. These steps generally fit into a consistent sequence (Figure 3) that, when followed, result in robust useful indicator sets. Each step in the process will be discussed in more detail throughout the remainder of this manual. In some instances, guidance documents previously developed by EPA provide greater detail on the steps. In cases where other documents already exist on these detailed processes, this manual will supply some of the highlights of the documents but will rely on the original documents to supply the entire process.

Many programs, such as the NEPs and NERRs, may have already completed a number of the steps outlined in this manual. Thus, to make this manual easier to follow and more user-friendly, we will use the flowchart in Figure 3 in the margins of the next few sections to show the step to which the accompanying text is referring. As the different steps in the process are explained in the text, a tab in the side margin will indicate where the text applies in the process (see example on page 16). This will allow groups to tab directly to the steps they are interested in.

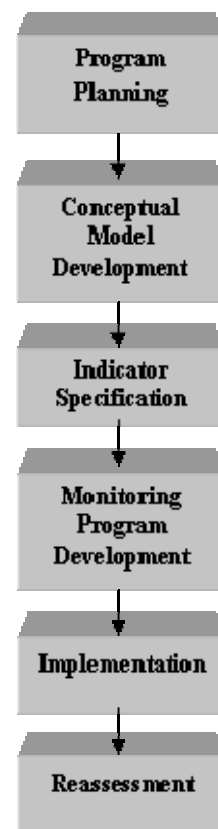
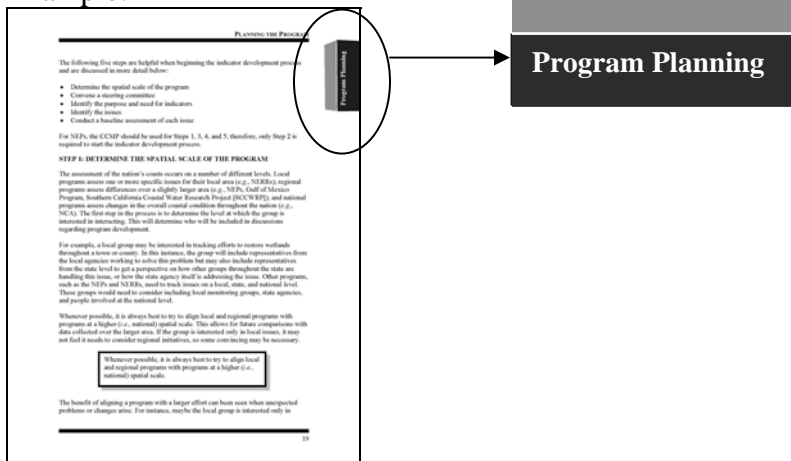


Figure 3. Indicator Development Process

INTRODUCTION

Example:



Case studies have been included from the Barataria-Terrebonne Program (Appendix A-1), the New Hampshire Estuaries Project (NHEP) (Appendix A-2), and the NCIW (Appendix A-3). These case studies represent successful programs that developed indicators in a local and regional area. In addition, as we move through the steps toward indicator development, examples of additional programs will be given to assist new programs in understanding the process.